# Characterization and modelling of anisotropic expanded austenite lattice curvature in plasma nitrocarburized 316L stainless steel

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**Abstract**

Austenitic stainless steels (ASSs) are characteristically selected for use in environments that demand high corrosion resistance: maritime, chemical, and nuclear applications, among many others. In an effort to improve their poor mechanical properties – specifically hardness and wear resistance – one may promote the formation of a hardened surface layer as a result of N, C, or N+C diffusion into the surface. This process leads to the occupation of interstitial octahedral sites in the fcc lattice by N and/or C, thereby distorting and expanding the near-surface lattice. The resulting metastable solid solution is hence referred to as expanded austenite. It is known that expanded austenite may form a single layer, $\gamma$N or $\gamma$C in cases of nitriding or carburizing; or a double-layer, $\gamma$N/$\gamma$C, in the case of nitrocarburizing.
The volumetric expansion of the fcc lattice at the surface generates significant compressive residual stresses due to geometric confinement by the substrate about the plate plane. These stresses exceed the yield limit, and as a result of the induced plastic slip, the expanded austenite region exhibits significant anisotropic curvature relative to substrate grains. There is limited extant literature addressing this phenomenon. This study investigates the coherence of observed cross-sectional lattice curvature in nitrocarburized AISI 316L stainless steel with known crystal plasticity models, namely the Sachs single crystal model and Taylor-Bishop-Hill polycrystal models.

Crystallographic characterization was conducted using Co-K$\alpha$1 x-ray diffraction and electron backscatter diffraction. Composition-depth data was extracted through glow-discharge optical emission spectroscopy and electron probe microanalysis. Correlative visual observations were made through light optical microscopy of etched samples and backscattered electron imaging of un-etched samples.
A plastic slip model for expanded austenite is thereby presented, corroborating microstructural characterization of the plasma-assisted nitrocarburized lattice distortion.

**Keywords:** Expanded austenite, Lattice curvature, Electron backscatter diffraction, X ray diffraction, Taylor model, Bishop, Hill mode

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